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NOTES ON GUNDLACHIA AND ANCYLUS

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ABOUT seven years ago,[1] in the *Nautilus* I called attention to certain problems connected with the genera mentioned in the title of this paper, and urged investigation of the subject from the hypothetical view of the two following propositions:

1. That *Gundlachia* is merely an *Ancylus* which under favorable circumstances has been able to form a calcareous epiphragm and survive the winter, which ordinarily kills the great mass of individuals, and, while retaining the shell of the first season, to secrete an enlarged and somewhat discrepant continuation of it during the second summer.
2. That not all Ancyli necessarily have the ability to do this, but the practise may have developed in certain small species; and in tropical regions where the dry season takes the place of winter it is possible that survival may become more or less habitual with some of these species.

In this connection attention may be recalled to the æstivation in dry mud behind a double epiphragm, in the Bahamas, of *Segmentina dentata* Gould,[2] and to the observations of Erland Nordenskjold[3] on *Ancylus moricandi* Orbigny, in Brazil.

During the past four years I have received an interesting series of notes by Mr. John A. Allen, of Cleveland, Ohio, connected with the Nungesser Electric Works of that city, who has for some time been domesticating in small aquaria species of fresh-water shells, including

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[1] *Nautilus,* XVII, No. 9, pp. 97–98, January, 1904.

[2] Smithsonian Miscell. Coll., Vol. 47, Pt. 4, No. 1566, pp. 446–448, April, 1905.

[3] *Zool. Anzeiger,* XXVI, pp. 590–593, July, 1903.

Ancylus and *Gundlachia*. His observations extend over some six years and his notes contain so much of interest that it has seemed desirable to summarize and publish his data, thus placing on record facts which may stimulate others to follow his example.

Mr. Allen was kind enough to send to the museum a lot of *Anacharis* supposed to contain both *Ancylus* and *Gundlachia* in the living state, and numerous specimens of the former were observed in a jar to which the vegetation was consigned, immediately after it was filled with water. We were not able to distinguish with certainty any *Gundlachia*, though some may have been present, and the small aquarium was kept in good condition to await developments. This was in December, 1907. The Ancyli continued to exist in apparent health during the winter. In May, 1908, they seemed to go into hiding, but during the summer reappeared again in rather diminished numbers, while a few young ones were observed. No particular change was noticed during the following winter and spring. While absent during the summer of 1909, it became necessary to transfer the collections to the new building of the National Museum and the aquaria were set aside. After the confusion of the transfer was measurably over, I examined the aquaria and, finding nothing visible, had the contents of the smaller one (about 8 × 4 × 10 inches in size) removed and submitted to the most careful scrutiny, the sand at the bottom being placed in a fine sieve for examination, but not a trace of *Ancylus* remained. I concluded that there had been sufficient carbonic acid in the water to completely dissolve these fragile shells after death, and that some unfavorable condition had exterminated the colony. In the other aquarium, which was about eight times the capacity of the smaller one, the water had evaporated to about half its normal quantity and no mollusks except a few small Lymnæas were visible, while the *Anacharis* had suffered considerably by the adverse conditions. This was towards the end of November, when it was difficult to get any fresh weed except by purchase. Being much occupied, I contented myself with having the aquarium filled with Potomac water from the tap. A short time afterward I was surprised to note a large number of young *Ancylus* with clean translucent shells, on the side of the tank. There had never been any *Ancylus* in the aquarium except such as might have been put in with Mr. Allen's *Anacharis.* These had up to February 22, 1910, grown rapidly and continued to flourish, though the number then visible was only about half that which was noticed in November. In April the *Ancylus* completely disappeared again. I have not been able to discover where they went to, as the most careful scrutiny of the sparse amount of *Anacharis* remaining has not revealed any on the stems or leaflets. None of the specimens seemed to have formed any septum and nearly all of them were carrying a small colony of five or six minute hydroids on the posterior upper surface of the shell. The shells in February were still too fragile to admit of removal from the glass without crushing, and most of them kept on the side away from the window, on the sill of which the tank stood. They were about 3.0 mm. in length, and remarkably active, moving about on the glass with surprising speed.

Subsequently Mr. Allen kindly furnished me specimens of all these stages in alcohol; and I also had the opportunity of seeing some specimens in alcohol which had been sent to Mr. Bryant Walker and Dr. H. A. Pilsbry in 1908, and which were obviously identical with those sent as examples by Mr. Allen to me over a year later, and Dr. Pilsbry thought also with specimens collected at Rockford, Illinois, in the ancyloid stage. On account of its relations to the *Gundlachia* it will be referred to here as *Ancylus meekiana,* since, unless in the *Gundlachia* stage, it seems not to have been described.

Mr. Allen also sent a lot of the wild *Ancylus* collected in the Thornburg lagoon and which he was disposed to regard as something distinct from his aquarium ancyloids. After a careful examination under the microscope I have been unable to find any constant differences between shells of the same age, except that the larger specimens of *Ancylus* seem to have grown continuously and evenly, while those ancyloids which attained a *Gundlachia* stage show the sharp contrast between the separate stage and that with the expanded third stage of the shell. As this is only what one might expect if the *Ancylus* attained its full growth without interruption, while the ancyloid becoming septate passed through a resting stage and then began to grow again, I consider this difference of no moment systematically. The young *Ancylus* and the ancyloid of the same length appeared generally quite identical, though I noticed that in both the obliquity of the apex varied to some extent, being more emphatically bent toward the posterior right side in some individuals than in others.

Ancylus meekiana is, when young, for a time nearly parallel-sided, the growth toward maturity being more expanded than at first. The apex is behind the middle of the shell and slightly inclined toward the posterior right-hand side at maturity. The microscope reveals some very feeble radial striæ from the apex, mostly vanishing before they reach the base. The incremental lines are not strongly marked and the shell when clean is of a pale translucent yellowish color. At or near maturity the shell assumes a more oval form slightly more expanded in front than behind. The animal has short pointed tentacles, well-marked black eyespots, and a bluish-white color, except about the mouth, where the yellow-brown jaws are laterally set and the buccal mass has a pinkish color. The shell is about 3.6 mm. long, 2.3 wide, and 1.0 high. In the dark-colored specimens of the wild *Ancylus,* on the inside, may often be seen a dark-brown line corresponding to the margin of the young *Ancylus* and showing the more parallel-sided early outline.

Miss Mary Breen, who has been studying the anatomy of the fresh-water gastropods of the District of Columbia, was kind enough to undertake the removal and mounting of radulæ taken from specimens of the different stages, as well as from the wild *Ancylus*. This was a task of no little difficulty on account of the extremely minute size of the organ. The radulæ of ancyloids, septates and *Gundlachia* were absolutely identical in appearance and in number of teeth, the formula 5·10·1·10·5, holding good for all. The uncinal teeth are not gradually modified from the laterals, but change abruptly and form a distinct band on each side of the radula. The lateral part of Stimpson's figure of the dentition of his *Gundlachia meekiana* is imperfectly made out, and obviously inaccurate; due doubtless to the fact that he had only a few specimens and a not very powerful microscope. Unfortunately his original material was destroyed in the great fire at Chicago of 1871.

An examination of the radula of a septate form, collected in Nicaragua by Professor B. Shimek, showed a similar radula but with one more uncinal tooth on each side. In this case, unfortunately, while endeavoring to transfer the minute object to a slide for permanent preservation, it mysteriously disappeared, and a trial with a second specimen was no more successful.

The form of the laterals is fairly well given by Dr. Stimpson, and the rhachidian tooth is correct in his figure; but the gradual modification and uncertain number of the outer teeth of the radula do not agree with our observations on the specimens from Ohio. Renewed correspondence with Mr. Allen led to the preparation of this paper, pending the continuation of his observations.

Since the different stages of *Gundlachia* need to be carefully discriminated, I have adopted the following nomenclature for them.

In the first stage, when the young shell has a laterally compressed subconical shape without any trace of septum, and is to all intents and purposes, conchologically and anatomically, an *Ancylus*, I call the individuals "ancyloids."

In the second stage when the base of the conical shell is more or less closed by a flat horizontal septum continuous with the margin around it, I call the individuals "septates."

Lastly, when the animal in its second season begins to form a marginal expansion external to the septum, and with its longitudinal axis sometimes at a considerable angle with the axis of the ancyloid shell, I reserve for this stage, up to and including maturity, the term "*Gundlachia.*"

Mr. Allen kindly sent alcoholic specimens of ancyloids, septates and *Gundlachias* from his aquarium for anatomical examination. The posterior part of the foot entirely hides the septum when the living animal on the walls of the aquarium is examined through the glass. Nothing to distinguish it from ordinary *Ancylus* is visible in the soft parts. The creatures feed on the microscopic algæ, etc., which grow on the walls of their domicile and when feeding the movement of the jaws and radula can be seen with ease by means of a magnifier. On the alcoholic specimens, on the exterior of the shell, were many minute lenticular capsules which, from analogy with *Neritina, Pompholyx*, etc., were supposed to be the ovicapsules. The very young shells are very transparent and fragile. It is difficult to find them until they have reached a length of over a millimeter, and so far it has proved impracticable to detach them from their roost without crushing them, they are so extremely fragile. The smallest septate seen was slightly less than two millimeters in length and the animal had entirely withdrawn behind the septum, which covers more than two thirds of the aperture.

The species in the *Gundlachia* stage agrees substantially with the form described from the District of Columbia by Stimpson, under the name of *Gundlachia meekiana.* As in many other fresh-water shells the newly formed shell is yellowish translucent, while the older part, especially when the pond or aquarium has a muddy bottom, often becomes darkened or even blackish, and more or less covered by a growth of conferva. Mr. Allen calls attention to the fact that the sharp line of demarkation which separates the dark encrusted shell of the septate from its translucent *Gundlachia* extension in the final stage, is evidence that the growth is not continuous, but that a resting period of some duration separates the two stages.

I have preferred for the most part to refrain from theorizing on the inferences to be drawn from the data, letting them speak for themselves. To me, however, the facts tend strongly to confirm the hypothesis suggested in the opening paragraphs of this paper.

General Notes

The following notes are partly summarized from a rather voluminous correspondence with Mr. Allen, extending over more than four years.

The Thornburg lagoon is an abandoned channel of the Cuyahoga River. In 1903 the river was fairly well stocked with Unionidæ, but soon after that date the contamination of the river by drainage and sewage killed off the naiad population. This contamination is not believed by Mr. Allen to have seriously affected the water of the lagoon, though for some reason it does not seem to be a place favorable to vigorous growth of mollusks. It produces a dwarf *Planorbis parvus*, a poorly developed *Physa*, a small form of *Lymnæa humilis modicella* and a scanty supply of *Amnicola*. It is nearly filled with *Nuphar* on the leaves of which *Ancylus* is found; also *Ceratophyllum*, *Potamogeton*, etc., occur, especially where the water is shallow.

At one place the bank bordering on the lagoon is steep and the water near it deep, so here even at low water mollusks would never be left dry. There is another portion of the lagoon where a wide zone, producing vegetation on which *Ancylus* occurs, is sometimes left uncovered when by dry weather the water becomes low. In this part of the lagoon three *Gundlachia* were found. In general the water of the lagoon is deep and constant, but owing to the presence of these shallows the hypothesis that the formation of a septum in *Gundlachia* may be due to alternation of wet and dry periods can not be wholly excluded.

Ancylus occurs in one to three feet of water where *Ceratophyllum* is abundant. In the deeper water shore there is more *Nuphar* and less fine vegetation the *Ancylus* seems to be absent or rare.

Mr. Allen attempted to domesticate the Thornburg *Ancylus,* placing many young ones in a 15 × 9-inch jar stocked with *Anacharis* from the lagoon. Apparently, all soon disappeared, although *Lymnæa* and *Amnicola,* coincidentally transferred, lived a long time.

NOTES ON THE SEVERAL JARS USED AS AQUARIA

The 15 × 9-inch Jar.—This originally contained a dwarf *Nymphæa* which died. There was a mixture of peaty and ordinary soil about three inches deep in the bottom of the jar. This was stocked in 1906 with *Anacharis* and some specimens of *Vivipara.* The date of the first appearance in it of the ancyloid stage of *Gundlachia* was not determined. February, 1907, individuals were very numerous and, some being taken out to save in the dry state, the septate form was discovered. Mr. Allen had noticed the presence of the ancyloid form some time before. The first date at which *Gundlachia* had been obtained from the Thornburg lagoon was July 15, 1906, but Mr. Allen doubts if the copious swarm of ancyloid individuals of *Gundlachia* could have originated in the jar so quickly from individuals accidentally put in at that time. Some of the vegetation in the jar had been received from elsewhere in Ohio, and some from another state. The ancyloid stage of the *Gundlachia* can not be distinguished from the associated *Ancylus* by the external features as seen in the aquarium. In February, 1907, probably hundreds of the unseptate ancyloid form were present. There were several *Vivipara* in the jar that winter. Subsequently they were removed, Mr. Allen thinking that they might consume the food supply needed by the ancyloids. Having heard that the stunted growth of aquarium mollusks might be due to the presence of their soluble excreta in the water, he thought the removal of the *Vivipara* might have had some influence in this way. However, the removal of the large snails did not stop septation.

In the winter of 1906–07 the specimens of *Planorbis parvus* in the jar were large and healthy. In the winter of 1907–08 the individuals of this species appeared dwarfed. The water in the jar was then removed and replaced by distilled water. After that the *Planorbis* (and Mr. Allen thought also the *Anacharis*) took on a more healthy appearance. He thought that the concentration of saline matter due to refilling loss from evaporation with ordinary lake water might have been influential injuriously, and the transfer to distilled water have lessened the tendency to septation.

In the winter of 1907–08 septate individuals of which the exact number were not recorded were again found in the jar. In January and February, 1908, the ancyloid form was fairly plenty, though not so numerous as in the previous year. In spring they became fewer and in May, 1908, there were none visible (although in a smaller jar there were some). They reappeared in the first half of June, 1908. July 3, 1908, an immature septate individual was taken, and another on July 20. On the theory that the septum is formed during a resting stage, these may have been forming during May, when nothing was in sight. August 3, 1906, another specimen was taken. January 11, 1909, a specimen was found which had begun to add the third or expanding stage of the shell external to the septum. No mature *Gundlachia* were taken from this jar during the winter of 1908–09.

August 19, 1909, a minute ancyloid specimen was taken, and another August 24. September 26 six ancyloids were visible at one time, but were not disturbed. It was noticed that the ancyloids came out in sight on the walls of the jar more freely on cloudy than sunny days.

This jar, December, 1909, contains a dense and vigorous growth of *Anacharis,* also plenty of fresh-water algæ. It stands in the factory room subject to the fall of factory dust, and to the changes of temperature in the room. When the room gets unusually cold the ancyloids mostly retire out of sight, temporarily. December 9, 1909, two specimens with the third stage of the shell partly grown were taken near the top of the jar. A sudden spell of unusually cold weather having begun two nights previous may account for the ancyloids having gone, as they did, into hiding, but it was somewhat surprising that the more nearly mature form had not also hidden.

The 8 × 6-inch Jar.—This had sand on the bottom and was planted with *Anacharis* from the larger jar, carrying with it *Ancylus, Gundlachia* and *Planorbis parvus* in the summer of 1908. The following winter, having nothing but sand and water to live on, the vegetation had become rather attenuated and feeble looking. The ancyloids were few and perhaps not more than half as large as those in the larger jar. January 19, 1909, two or three immature septate specimens were taken from this jar, and February 10 one about half grown. Very few ancyloids were seen about this time in this jar. February 11 two immature septate specimens were taken, being all of either form which were at that time visible. February 24, 1909, for the first time since the eleventh, a small ancyloid was noticed. On the twenty-seventh one moderate-sized but fully septate individual was taken and one ancyloid seen. Another septate was taken March 8, and March 11–13 a solitary ancyloid was noticed.

Fearing that there was not enough stock in the jar to continue the race, March 15, Mr. Allen put in half a dozen ancyloids from the large jar. March 29 a mature septate was taken out, and it was noticed that the *Planorbis* looked frail as if insufficiently supplied with lime salts. October 11, 1909, two half-grown septates were taken from this jar. In the winter (1909–10) the *Planorbis,* for some unknown reason, completely disappeared.

From these data Mr. Allen concludes that about 80 per cent. of the stock in this jar had assumed the septate form, the conditions obviously being such as to stunt both *Anacharis* and ancyloids. In the 15 × 9-inch jar the vegetation is luxuriant and abundant, and the septate individuals produced were only about two to five per cent. of the ancyloids. From this Mr. Allen concludes that the formation of a septum is promoted by causes which tend to restrict or retard growth.

The 9 × 7-inch Jar.—This has a mixture of sand and soil at the bottom. There is plenty of algal growth, but the *Anacharis* is not as vigorous as in the 15 × 9-jar, from which it was stocked with ancyloids and *Planorbis.* In the winter of 1906–07 it yielded two septates. The winter of 1907–08 ancyloids were fairly numerous, more so than during the first winter, but no septates were detected. July 1, 1908, young fry, hatched that season, were visible. March 8, 1908, a fine large mature *Gundlachia* was taken. The original ancyloid part was deep black and the flaring expansion beyond it was colorless and transparent. In the sand-bottomed jar the mature *Gundlachia* is uniformly yellowish translucent, but in the large jar with mud bottom the whole shell gets blackish. December 13, 1909, a census of this jar was attempted. The day was dark and a count difficult, but the result was six septates and two ancyloids, all eight being small and immature.

A Jar without Planorbis.—Thinking it might be desirable to have a stock of the ancyloids not associated with *Planorbis,* Mr. Allen, about February, 1909, when the *Planorbis* was not breeding, transferred some *Anacharis* and a number of mature ancyloids to a new 15 × 9-inch jar, taking care not to introduce any *Planorbis*. May 3, 1909, the first ancyloid hatched in the jar was noticed; it was about half the size of the parents. Others appeared later. By December, 1909, the parent stock had disappeared and the stock hatched in the jar remains very small, indicating some unfavorable condition. The bottom of the jar was covered with a mixture of ordinary and swamp soil, but the supply of swamp soil used in previous jars having been used up, that in the present jar was taken from another place, and may have contained some unfavorable matter. The *Anacharis* in the jar is fairly flourishing, but there is no green algal growth.

General Conclusions.—The *Gundlachia* may reproduce before assuming the completely mature form. The shell varies in apparent color in accordance with the muddy or sandy character of the bottom soil, but the dark coating in the former case is not incorporated with the shell structure.

The ancyloid stage has a period of least activity in May. In July and August the septates appear. In autumn and early winter the third stage is developed, becoming mature and complete in February or March. This course is, however, not invariable in the aquarium or domesticated specimens, since Mr. Allen has taken ancyloids in January or February, an irregularity probably due to temperature and which might not have occured in specimens under perfectly natural conditions. It is not certain that the ancyloids detected by Mr. Allen in July and August were the young of that season, since the minute creatures are very difficult to detect in the aquarium and can not be handled. They are so translucent in the younger stages as to be practically invisible. However, it is probable that the eggs are laid during the winter and hatched in the very early spring.

It seems likely that under average conditions only a small proportion of the individuals advance beyond the septate stage; and also that, of the ancyloids, only part reach that stage. It is also probable, from Mr. Allen's observations, that anything which tends to retard development may coincidently increase the tendency to form a septum.

Since there is a period of least activity in May, a natural observation year will be from one May to another. Mr. Allen summarizes the results obtained during the period, May, 1908, to May, 1909, as follows:

None being taken before July nor after the following March, there were secured between July, 1908, and March, 1909, inclusive:

15 × 9-inch jar 4 septates
9 × 7-inch jar 1 septate } total 15.
8 × 6-inch jar 10 septates

From August 19, 1909, to December 13, 1909:

15 × 9-inch jar 8 septates
9 × 7-inch jar 6 septates } total 16.
8 × 6-inch jar 2 septates

Further correspondence, during February, 1910, affords additional notes.

A lot of the wild Thornburg *Ancylus* in alcohol was sent by Mr. Allen and, contrary to his expectation, on careful comparison with his series of ancyloids from his aquaria, no difference, beyond slight individual variations, could be observed in the shells of the two series, while the radula and the soft parts, after repeated comparisons, seemed to be identical in both.

Mr. Allen especially notes that in the winter, 1909–10, the septates were the prevailing form in his aquaria, exactly the reverse of the case when the aquaria were freshly established. The generation, which appeared in May and June, 1909, in the "*Planorbis*-free" jar, was dwarfed was not in sight during the latter part of the winter, 1909–10, and may possibly have all died. Mr. Allen attributes the poor success of this jar to the use of swamp soil from a different place from that previously used.

February 15, 1910, being a dark day and therefore favorable for the septates to be out of sight, Mr. Allen counted those visible in the large aquarium. Six septates and one ancyloid were noted. This illustrates the observation that (excepting the "*Planorbis*-free" jar) the septate is the prevailing form this season, and is promoted by causes which dwarf or retard growth.

After noting the inexplicable way in which fresh-water mollusks sometimes appear and disappear from pools where they occur, Mr. Allen further suggests that the septate form may be a prelude to total disappearance of the species from a given place.

Another count on February 17, 1910, gave three ancyloids and three septates in sight, which Mr. Allen remarks is the first time for a considerable period that the two forms have appeared in equal numbers. In the large jar every mature specimen seen this season has been conspicuously bicolored, the ancyloid or septate part being stained deep black, while the flaring extension is translucent and colorless, indicating that a resting period intervened between the completion of the septum and the formation of the mature shell.

Three ancyloids seen February 17 were all translucent and about the same size. There can be little doubt that they date from the summer of 1909. Hence, Mr. Allen infers that the blackened original shells of the mature *Gundlachia* date from the season previous.

TABLE FOR JANUARY AND FEBRUARY, 1910

Specimens taken or observed

Date	Gundlachia	Septates	Ancyloids
January 12 (big jar)	1	1	0
January 19 (big jar)	1	0	0
January 31 (small jar)	1	0	0
February 4 (big jar)	2	0	0
February 5 (big jar)	3	1	0
February 6 (medium jar)	0	2	0

My last communication from Mr. Allen, dated December 11, 1910, contains the following additional notes:

> As I have already written there was plenty of A-form (ancyloids) and no G-form (septates) visible in my original large jar last summer. But, since the latter part of November, besides ancyloids in various stages, young septates have been visible in fair abundance. I counted about a dozen in sight at one time.

He concludes that ancyloids are present most of the year, but only young ones in May and mostly also in June. But septates appear to be a strictly winter form, that is, the immature septate stage appears in August or later, reaches maturity (*Gundlachia*) in February or March, and disappears about the end of April, after which and a shorter or longer interval the young ancyloids of the season begin to appear in the jars.

If the hypothesis stated at the beginning of this paper be well founded, it would explain why mature *Gundlachias* appear, if at all, usually as a few individuals in any given locality, and their presence can not be counted on, as in the usual case of fresh-water mollusks, and is distinctly a rarity in the temperate regions of the continent, where there are no well-defined wet and dry seasons.